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**LIST OF TRANSLATED DOCUMENTS:**

German Patent Application PCT-EP2005-002712, *Automatic Braking and Locking of a Wind Turbine*

Signature: \_\_\_\_\_

*Katja I. Suletzki*  
Katja I. Suletzki, Latitude48 Translation

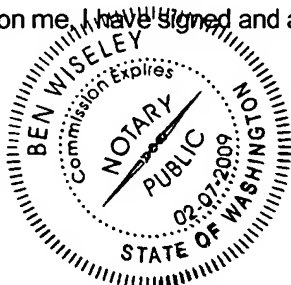
Date: \_\_\_\_\_ July 6, 2006

### NOTARY STATEMENT

State of WASHINGTON     )  
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I, Ben Wiseley, Notary Public in and for said County and State, do hereby certify that on this day, Katja I. Suletzki, personally known to me to be the same person and official who executed the above and foregoing statement appeared before me in person and acknowledged that she executed the above statement as her free and voluntary act.

Pursuant to authority conferred on me, I have signed and applied my seal on this day.



Signature: \_\_\_\_\_

Date: \_\_\_\_\_ July 6, 2006

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## **Automatic Braking and Locking of a Wind Turbine**

The invention pertains to a process for the operation of a wind energy installation by which a rotor of the wind energy installation is decelerated and locked in a desired rotational position with respect to rotation about the rotational axis, as well as a wind energy installation capable of executing such a process.

In general, wind energy installations consist of a tower, of a nacelle mounted on the tower that can be rotated on an approximately vertical rotational axis, as well as of a rotor attached to the nacelle so as to be able to rotate on a usually horizontal rotational axis.

The rotor of conventional wind energy installations comprises a hub and usually two, three or four rotor blades, with the blades fanning out from the hub radially to the rotor axis. In order to adapt the characteristics of the rotor to prevailing wind conditions, the rotor blades are usually rotatable with respect to rotational axes aligned radially to the rotor axis. For this purpose, hydraulic cylinders and/or servo-motors with the necessary gears are built into the hub. These servo-motors as well as the gears and generators downstream of the rotor, which are also usually mounted on the nacelle, represent a source of malfunction during operation of the wind energy installation. Repair and maintenance personnel must be able to access the parts of the installation that are mounted in or near the rotor hub. For this purpose, and in order to avoid damage to the wind energy installation, the rotor must be stopped and locked.

According to the applicable guidelines for the certification of wind energy plants, provision must be made for the positive locking of the rotor. For this purpose, pins or locking devices are usually used that fit into disks coaxially attached to the rotor in a non-rotatable manner. Conventional locking pins are fixed with respect to rotation on the rotor axis and are braced in the required rotational direction on the frame structure of the wind power installation, in this way making possible a positive locking with respect to rotation on the rotor axis, in concert with the disks that are non-rotatably attached to the rotor. To reach the locking position, the pins of conventional locking devices are adjusted manually or hydraulically along the axis of the pins which runs approximately parallel to the rotor axis between a release position and a locking position, in which the pins fit into a recess in the disk. To obtain the required locked position, an aerodynamic and/or mechanical brake is applied to the rotors of the wind power installation until they come to a standstill. Then the locking pin is moved to the locking position in which it fits into the recess in the disk. It has become evident that the conventional way of locking cannot be accomplished without the use of service personnel on the nacelle. This not only represents higher costs but also increases the risk for maintenance personnel, who must be ferried to the top of the nacelle, which in the case of modern wind energy installations is usually mounted at a height of 100 m or more, while the rotor is in motion.

In view of these problems in the state of the art, the invention addresses the task of making possible a cost-effective process for the operation of a wind energy installation that represents little risk, as well as to show a wind energy installation that solves this problem.

According to this invention, this task is solved by further development of conventional processes for the operation of a wind energy installation that is mainly characterized by the fact that the rotational position of the rotor with respect to the rotor axis is recorded, at least when it is in the desired rotational position, the rotor is stopped in the desired rotational position and, preferably, locking is automatically initiated when the desired rotational position has been reached.

The invention is based on the recognition that the need for personnel use when locking the rotors of conventional wind energy installations is primarily required by the fact that after braking the rotor has not yet reached the desired rotational position and that therefore the locking pin cannot be introduced into a corresponding recess in the locking disk. The braking mechanism must therefore once again allow free rotor movement. After renewed braking, another attempt can be made to fit the locking pin into the recess of the locking disk. In order to avoid a large number of such attempts, continued monitoring of the locking process by maintenance personnel is necessary. If the process according to the invention is used, the use of personnel for the locking process is no longer necessary, because the desired rotational position is automatically determined using appropriate monitoring devices, the rotor can be stopped in the desired rotational position, and locking can then automatically be accomplished safely and reliably without additional control by maintenance personnel.

In this way costs for maintenance activities are reduced considerable, and the risk for maintenance personnel is limited to a minimum. The risk is posed not only by the rotating parts of the installation during the locking process but also by the fact that the maintenance personnel must be ferried to the top of the nacelle by helicopter; since wind conditions change continually even when the rotor is turning only slightly, the approach becomes especially difficult.

In the process according to the invention, it is especially easy to determine the desired rotational position of the rotor if the rotor possesses a marker that rotates with it and the position of which can be recorded by an appropriate position sensor. In view of the guidelines for certification of wind energy installations, it is especially useful if for the locking process a locking element connected to the rotor in a non-rotatable manner is made to engage with a further locking element that is fixed with respect to rotation on the rotor axis. The locking element may, as is the case with conventional wind energy installations, have a disk arranged concentrically to the rotor axis and provided with at least one recess, so that for locking the additional locking element in the form of a locking pin that is approximately parallel to the rotor axis is inserted into the recess, with the locking pin preferable braced against a part of the frame structure of the wind energy installation. Movement of the locking pin may be accomplished by electrical,

electromechanical, magnetic or pneumatic means. Inserting the locking pin into the recess by hydraulic means has been shown to be especially advantageous.

Using the process according to this invention, it has been shown to be especially useful for the avoidance of damage to the locking device and other parts of the installation if the rotor is decelerated preferably by aerodynamic and/or mechanical means and if the brake is released as soon as the second locking element engages with the locking element that is non-rotatably connected to the rotor. The position of the second locking element and/or the locking element that is non-rotatably connected with the rotor can be recorded by means of an appropriate position monitoring device, and the locking process and/or the deceleration of the rotor can be regulated according to the position that has been recorded. It has been shown to be especially useful in this connection if the mechanical brake is released as soon as the locking pin has been partially introduced into the locking disk. The locking pin can then be inserted fully into the disk by hydraulic means. As soon as the locking pin has reached its final position, this position is recorded by the position monitoring device, which may take the form of a position switch, and completion of the process is reported to a central control device. In order to facilitate insertion of the locking pin into the disk that is non-rotatably connected to the rotor, the pin may have a conically tapering cross-section on the face pointing toward the disk as the pin approaches the disk. The process according to the invention can be executed in a fully automated manner if the braking process and the locking process are controlled by a central control device, which in turn may be controlled by a wireless command signal.

As specified in the above description of the process according to the invention, a wind energy installation according to the invention is characterized mainly by the fact that the rotor is accompanied by a monitoring device that determines whether a desired rotational position has been reached and generates an appropriate signal, and that the rotor may be locked automatically in response to this signal when the desired rotational position has been reached.

Below, the invention is described with reference to the illustration, which should be referred to regarding all details that are essential to the invention and that are not further explained in the description.

The single figure of the drawing shows a schematic representation of a wind energy installation according to the invention.

The wind energy installation represented in the illustration consists of a rotor designated in its entirety by number 10, a locking devices designated in its entirety by 20, as well as a braking mechanism designated in its entirety by 30. Rotor 10 comprises a total of three rotor blades 16 that extend radially to rotor axis 14 from a rotor hub 12. A locking disk 22 of the locking device 20, arranged coaxially to the rotor axis, is non-rotatably connected to the rotor axis 14. The locking disk 22 is provided with a total of six recesses 24. The centers of the recesses 24 are arranged on a circular line that is coaxial to rotor axis 14. In addition to the locking disk 22, the locking device also comprises a locking pin 26, which, in the desired rotor positions, can be inserted into the recesses 24 by moving the pin 26 in the direction indicated by arrow 28 in parallel with rotor axis 14. The locking pin 26 is fixed with regard to rotation on rotor axis 14 and is supported by a frame structure that is schematically indicated at 28.

The braking arrangement 30 comprises a brake disk 32 that is non-rotatably connected to rotor axis 14 and arranged coaxially to it, as well as brake shoes indicated in their entirety by 34. The brake shoes 34 are movable in parallel to rotor axis 14 and are fixed with regard to rotation on the rotor axis 14 by being braced at 36 against the frame structure. In order to block rotor 10, the process according to the invention decelerates the rotor by means of an aerodynamic or mechanical brake 30 to a rotational position that allows the locking pin 26 to be inserted into one of the recesses 24. The rotor's rotational position is determined by a marker at locking disk 22 and a position sensor. As soon as the rotor comes to a standstill at the desired rotational position, locking pin 26 is automatically inserted hydraulically into locking disk 22. The position of locking pin 26 (not blocked/blocked) is controlled by positional switches. As soon as the pin has been partially inserted into the appropriate recess 24, the mechanical brake 30 is released and, with the help of its slightly conical shape, the pin can be hydraulically inserted fully into recess 24. When the pin has reached its final position, this fact is recorded by a position switch (not shown) and completion of the process is signaled to a central control device (not shown).

In this manner the wind energy installation's rotor is blocked automatically. An essential advantage of an automated locking of the rotor lies in the fact that the installation can be decelerated and locked by means of remote control or by a switch at the control console in the base of the wind installation's tower. The service personnel can then access the installation, including the rotor hub, without having to conduct further locking activities. This increases safety for the maintenance personnel and saves time.

Today's ever increasing installation output and rotor diameter require ever stronger and therefore heavier locking devices. Manual actuation and especially manual positioning of the locking disk is very difficult for the service personnel, especially since the rotor has to come to a complete standstill before locking can be effected. If the rotor continues to turn slightly as the locking device is inserted, the locking device may be damaged because of the large mass moment of inertia in the rotating system. This kind of damage occurs not infrequently.

This problem is solved by automated locking using the process according to the invention.

When wind energy installations are deployed off-shore, their accessibility may be restricted by high waves or ice. At times the installations are accessed by helicopter and service personnel are ferried to the top of the nacelle (turbine house). These maneuvers are very risky because wind conditions vary continuously as the rotor continues to rotate slowly. A rotor that has been safely blocked using remote control and the process according to the invention without the use of service personnel increases work safety. Locking can be initiated by a remote-control command signal using an automated system.